

V/PRTS

10/529325
JC17 Rec'd PCT/PTO 25 MAR 2005

Ferritic Steel Alloy

The present invention relates to the field of high-alloy stainless steels that are used in the watch industry.

The majority of wristwatches that are worn nowadays
5 are made from gold, stainless steel and titanium. The
development of steels for watches commenced in 1925 when the
English firm Firth Vickers Special Steels Ltd. introduced the
CrNi steel designated "DDQ" to the market. At about the same
time, the firm Krupp developed the steel V2A, but this only
10 started to be used in the watch industry 50 years later, as
steel No. 1.4301. Then, at the end of the 1980s, the steel
"DDQ" was replaced by austenitic stainless steel No. 1.4435,
which is nowadays the standard steel, on account of the
demand of the Swiss watch industry for an improved resistance
15 to corrosion.

Watch casings are normally produced from metal sheets
and panels using die cutting techniques. In order to achieve
their desired final form, depending on the watch casing type,
they have to be to some extent strongly cold compressed and,
20 depending on the height of the casing, be intermediately
annealed. The same is also true for the production of
profiles for straps by cold rolling. The cold hardening
behaviour is of crucial importance for cold massive forming.
In general, the steel most suited for this type of
25 deformation is that which at low yield strength values least
cold hardens itself with increasing deformation grade. The
ferritic stainless steels behave in the annealed state during
massive forming similarly to unalloyed steels.

In order to protect the parts of a watch mechanism that are sensitive to magnetic influence from strong magnetic fields, some watch makers have incorporated a soft iron cage in watch casings of titanium or the stainless steel of type 1.4435 mentioned above (this material does not possess in its own right magnetic shielding properties). This soft iron cage has the role of a protector against magnetic fields, which does not let magnetic fields penetrate into the watch. Thereby a watch can indeed be protected against magnetic fields up to 80 000 A/m; the effort necessary is however considerable, since this soft iron cage must be separately finished and then incorporated into the actual watch casing, whereby the overall height of a wristwatch is significantly increased.

The polishability of a steel, i.e. its suitability for the production of a high-gloss polished surface, for example for casings, is a further demand on a watch steel. This requirement is only fulfilled to a limited extent by the austenitic steel No. 1.4435 which is currently used in the watch industry. Ferritic steels such as the steel no. 1.4521 are not as polishable as austenitic steels: the ferritic steels are almost exclusively stabilised with titanium or Nb, in order to avert the precipitation of Cr-carbides on the grain boundaries. Thereby, however, titanium carbides or niobium carbides of high hardness precipitate, which destroys the polishability of the ferritic steel. The precipitated carbide particles of magnitude of 5-10 μm are not removed with mechanical polishing and protrude as so-called craters out of the surrounding, better polished surface. So-called polishing tails arise, i.e. deposits of polish paste in the polish shadows of the carbide particles, which are extremely

disturbing to the naked eye. For a polishable ferritic chromium steel, the stabilization of the steel microstructure through additions of Ti or Nb is thus not applicable, due to the negative influence on the polishability. However, without
5 stabilization of the microstructure with Ti or Nb, the precipitation of carbides of chromium on the grain boundaries progresses due to the diffusion speed, which is for ferritic steels about 2 orders of magnitude higher, so quickly that it can also not be avoided by rapid quenching from the solution
10 annealing temperature. Also the chromium carbides form hard inclusions, which again mar the polishability of a steel.

The polishability of a steel is also critically influenced by the grain size. Polishing of large-grain steels produces what is known as an orange-peel effect, which is
15 unacceptable for polished surfaces. The reason for this is the different properties in the various directions of the unordered grains (crystals). If the grain size, measured in accordance with ASTM E 112, is inferior to the value 4 ($\geq 80 \mu\text{m}$), the human eye can recognise the crystal surfaces that
20 have been removed to different extents during the polishing process as spot-like particles, which gives the appearance of an orange peel.

A further requirement in the specification of a watch steel, is good processing properties. Depending on the type
25 of casing, a wide range of cold-forming operations with intermediate annealing steps have to be carried out during the production of watch casings. Moreover, the production of straps, where e.g. drilling and milling are used, in addition requires good machinability of the alloy.

A good resistance to corrosion, in particular in salt-containing media, is a further main requirement of a watch steel. Wristwatches are in direct contact with the skin and are at particular risk of corrosion on account of the aggressiveness of perspiration. The purity of a steel has a considerable influence on the resistance to corrosion. Coarse and linearly disposed non-metallic inclusions represent a weak point at the surface, at which pitting can commence and then continue unimpeded. For this reason steels in the art are often remelted according to the Electro-Slag-Remelting method (ESR-method), that leads to a decrease of the non-metallic, corrosion fostering particle sizes around about 2 units according to DIN 65602.

It is known that the chemical and mechanical properties of steel alloys can be controlled by the addition of metallic and non-metallic elements to the alloy.

The influence of each individual alloying and trace element on its own on the mechanical, chemical and magnetic properties and the microstructure of a steel are known (cf. for example Chapter 2.2 in "Nichtrostende Stähle - Eigenschaften, Verarbeitung, Anwendung, Normen" [Stainless Steels - Properties, Processing, Use, Standards], 2nd Edition, Editor "Edelstahl-Vereinigung e.V." Verlag Stahl-Eisen; and "Stahlschlüssel" 18th Edition 1998, Chapter 1, by C.W. Wegst, Verlag Stahlschlüssel, Wegst GmbH).

Known alloying elements, and their effects on steels if they are added to the alloy individually, are briefly outlined below.

Firstly chromium has a passivating effect on the steel and therefore represents the main alloying element for all stainless steels.

Molybdenum increases the resistance to corrosion and
5 the stability with respect to pitting corrosion in the presence of halide ions.

Silicon is rather to be regarded in polishable steels as an undesired impurity, since it forms hard oxide inclusions. On the other hand, silicon is a desired alloying
10 element, if the alloy should be magnetically soft.

Nitrogen improves the resistance to corrosion. Since the yield strength and the tendency to work-hardening are increased by the addition of N, the N content is generally restricted to 0.2%. Additions of N in austenitistic steels
15 are supposed to greatly delay the commencement of $M_{23}C_6$ precipitation. (P. R. Levy, P.R., van Bennekom, A., Corrosion 51, 911-921 (1995)). On the other hand the presence of nitrogen is troublesome, if an alloy with magnetically soft properties is desired (see e.g. "Ullmann's Encyclopaedia of
20 Industrial Chemistry" Fifth Edition, Volume A16, page 26, left column, 2nd paragraph).

Manganese is an austenite-forming element. Its presence is therefore rather undesired in a ferritic steel.

Small traces of sulphur are of benefit to the
25 machinability of the steel, which may be important in view of the production of specific watch parts, such as for example straps. However, in large quantities it has an adverse effect

on the corrosion resistance of the steel.

Although the addition of carbon improves the hardness of a steel, it is however, on the other hand, a very strong austenite-forming element and it reduces the machinability and polishability by the precipitation of chromium carbides on the grain boundaries. The presence of carbon is likewise very troublesome if an alloy with magnetically soft properties is desired (see e.g. "Ullmann's Encyclopedia of Industrial Chemistry" Fifth Edition, Volume A16, page 26, left column, 2nd paragraph).

With regard to the magnetically soft properties of a steel alloy, nickel would be desirable as an important alloying element (typically 30 to 80 percent by weight), it is, on the other hand, however rather unsuitable for a ferritic steel due to its property as an austenite-forming element. In addition allergic reactions to Ni-containing alloys have become in industrial countries a serious medical problem. In Europe, for example, more than 20% of young women and 6% of young men suffer from a nickel allergy. This is important in the casing of wristwatches, since these directly lie on the skin.

Pure, unalloyed iron (soft iron) is likewise favourable as a magnetically soft material, however, it is known not to be corrosion resistant.

The two dimensional microstructural phase diagram of the chromium-nickel steels allows a rough estimate to be made of the microstructure (austenite, δ -ferrite, martensite or mixtures thereof) which will form as a function of the Cr-

content (plotted on the x-axis in the diagram) and the Ni-content (plotted on the y-axis in the diagram). This microstructural phase diagram can also be expanded by taking further elements into account; however, the additional
5 elements are only taken into account in summary and estimated form as additional nickel or chromium equivalents. In this form it is known as the Schaeffler-diagram. (A.L. Schaeffler: M.S. Thesis, Univ. of Wisconsin, June 1944; A.L. Schaeffler, The Welding Journal 26/10, 601-620 (1947); A.L. Schaeffler,
10 Metal Progress vol. 56 s. 680A,B (1949)). Since converting the quantity of additional elements into equivalent quantities of chromium and nickel by calculation is carried out by means of empirically determined factors (cf. for example Briggs, J.Z., Parker, D., Climax Molybdenum Company
15 pages 6-7 (1965)) as values gained from experience, an accurate prediction of the microstructure for a specific alloy is nevertheless not possible. In particular, it is not possible to draw conclusions as to the corrosion resistance or the mechanical and magnetic properties of an alloy from
20 the Schaeffler diagram.

A rudimentary estimate of the resistance to pitting corrosion of a Cr/Mo steel can also be obtained from a two-dimensional diagram (Gräfen, H., Chem. Ing. Techn. 54, p. 108-119 (1982)). In this diagram the dependency of the limit
25 potential for the start of pitting corrosion (Y axis), as determined by means of the current density/potential curves, is plotted against the Cr content (X axis). The molybdenum content is also taken into account in the form of chromium equivalents (ibid and Lorenz, K., Medawar, G., Thyssen-
30 Forschung 1, p. 97-108 (1969)). An about linear correlation between the limit potential and the Cr(Mo) content is

observed. However, this diagram does not take into account any further alloying elements and does not allow conclusions to be drawn about whether it concerns a ferritic alloy, or about their machinability, polishability and magnetic properties.

The effective sum WS, which is defined in the following way:

$$WS = \%wt\ Cr + 3.3 \times \%wt\ Mo + 16 \times \%wt\ N,$$

is a measured value to roughly estimate the corrosion resistance of steels. Since perspiration on the skin is more corrosive than the 0.9% salt content of blood, watch steels should at least have the effective sum of an implant steel of 26.

Table 1 gives an overview of eight specific, prior art steels (designated by means of their material numbers) and their contents of important alloying elements in percent by weight. According to the knowledge of the applicant, the steel No. 1.4521 which is mentioned there, is not a watch steel.

Table 1

	1.4521 DIN 10088	1.4523 Steel- Iron-L.	Sandvik (Richt) 1802	Aichi (Ist) YUS 190	Aichi (Ist) SUS 444	NAR 445	NARFC3	NTK U-22
C	≤ 0.025	≤ 0.030	≤ 0.03 (C+N)	0.004	0.025	≤ 0.020	≤ 0.025	≤ 0.025
Si	≤ 1.00	≤ 1.00	0.5	0.06	0.87	≤ 0.60	≤ 1.00	≤ 1.00
Mn	≤ 1.00	≤ 0.50	0.3	0.06	0.21	≤ 0.60	≤ 1.00	≤ 1.00
P	≤ 0.040	≤ 0.040	--	0.025	0.032	≤ 0.040	≤ 0.040	≤ 0.040
S	≤ 0.015	0.15-0.35	0.3	0.008	≤ 0.002	≤ 0.010	≤ 0.005	≤ 0.030
Cr	17.0-20.0	17.5-19.0	18	18.8	17.8	19.0-21.0	19.0-22.0	21.0-23.0
Mo	1.80-2.50	2.00-2.50	2.3	1.86	2.07	1.70-2.30	0.75-1.25	1.75-2.50
Ni	--	--	≤ 0.20	--	0.17	--	--	--
N	≤ 0.03	--	--	0.009 ³⁾	0.025 ³⁾	--	--	≤ 0.025
Al	--	--	--	--	0.006	--	--	--
Ti	≤ 0.80 ¹⁾	0.30- 0.80 ²⁾	0.6	--	0.005	--	--	--
Nb	--	--	--	0.15	0.57	--	0.15	ca. 0.80
Cu	--	--	--	--	0.04	--	0.08-0.30	--
Fe	Remainder	Remainder	Remainder	Remainder	Remainder	Remainder	Remainder	Remainder

1) Ti = 4 x (C + N) + 0.15 to 0.80

2) Ti = 0.30 to 0.80 with (C + N) ≤ 0.40

3) N not explicitly added, only impurity

The object of the present invention is to provide a polishable ferritic steel, which has magnetically soft properties, in which the risk of polish defects is minimised, which has comparable mechanical properties to steel No.

5 1.4521 and has the same or improved corrosion resistance with regards to pitting and crevice corrosion as compared to the steel No. 1.4435.

The object is achieved by a steel alloy comprising, based on the alloy, at the most 1.00 percent by weight
10 silicon, 18.0 to 22.0 percent by weight chromium, 1.80 to 2.50 percent by weight molybdenum, 0.01 to 0.10 percent by weight nitrogen, at the most 0.01 percent by weight titanium, at the most 0.01 percent by weight niobium, at the most 0.01 percent by weight aluminium and as the remainder
15 substantially iron. Preferred variants are given in the dependent claims.

The steel alloys according to the invention are magnetically soft CrMoN-steel alloys.

Description of the figure

20 Figure 1 shows current density/potential curves of a) of a steel alloy according to the invention, and b) of a known steel alloy No. 1.4435. Measurement conditions: 3.2% NaCl, pH 4.0, 40°C. x-axis: Potential in mV against saturated calomel electrode (SCE) as reference electrode; Y axis: the
25 logarithm of the measured current density. The potential value indicated in the two figures is the limit potential at which pitting corrosion (strong increase in anodic current)

commences.

In the context of the present application, the term "high-alloy" has the meaning which is customary in the art, i.e. it designates a steel in which the alloying elements
5 amount to a total of 5 percent by weight or more.

In the context of the present application, the term "ferritic" means that at least 98 percent by volume, preferably at least 99.5 percent by volume, and especially preferably 100 percent by volume of the iron present in the
10 alloys according to the invention, is present as ferrite, wherein the determination is made by metallographic means.

In the context of the present application, the term "magnetically soft" is used for steel alloys according to the invention, which produce a magnetic shielding effect at least
15 as strong as soft iron.

The metallic alloying elements chromium and molybdenum can be added according to customary methods to the alloys according to the invention by addition of suitable quantities of the pure elements to pig iron or to crude steel.

20 According to the invention, there is 18.0 to 22.0 percent by weight, preferably 19.5 to 20.5 percent by weight and especially preferably about 20 percent by weight, of chromium, based on the finished alloy.

25 According to the invention, there is about 1.80 to about 2.50 percent by weight, preferably about 1.90 to 2.10 percent by weight and especially preferably about 2 percent

by weight, of molybdenum, based on the finished alloy.

Nitrogen can be supplied by melting the steel alloy in a nitrogen atmosphere, by blowing nitrogen into the melt or by adding dosed amounts of prealloys with a high-nitrogen content. According to the invention, the content of nitrogen is about 0.01 to 0.10 percent by weight, based on the alloy, more preferably about 0.05 to about 0.10 percent by weight and especially preferably about 0.05 percent by weight.

Silicon can be present as SiO_2 (for example from the above deoxygenation) in the alloy. Its content can be reduced by mechanically moving or agitating the steel melt under protective gas. In this way, the SiO_2 coagulates and rises up to the slag surface due to the low density. According to the invention, the content of silicon is at the most about 1 percent by weight, preferably about 0.7 to 0.9 percent by weight and more preferably about 0.8 percent by weight, based on the alloy.

Significant quantities (4 to 4.5%) of carbon are present as an admixture in the pig iron as a result of the smelting process, and this carbon content can then be reduced to virtually any desired level, as is customary in the art, by the addition of oxygen or suitable quantities of iron oxides to the steel melt (transforming the carbon into carbon monoxide). Preferably, according to the invention, there is at the most 0.025 percent by weight, especially preferably at the most 0.01 percent by weight, of carbon, based on the alloy.

Sulphur originates from the smelting process (iron

sulphides contained in the iron ore) and is mainly in the form of manganese sulphide in the pig iron. In the alloys according to the invention, it is preferably present in quantities of at the most 0.03 percent by weight, more preferably of at the most 0.002 percent by weight. It is possible to achieve such low sulphur content by desulphurizing the melt using, for example, mixtures of CaO and metallic magnesium. In another special embodiment of the steel alloy according to the invention, which has better machinability combined with a polishability which is still acceptable, the sulphur content may be at the upper limit of 0.03 percent by weight, preferably at about 0.015 to 0.03 percent by weight, based on the alloy (so-called IMA qualities), wherefore a regulated addition of sulphur can be carried out. For the production of this special embodiment, a melt metallurgy may be utilised with the addition of Ca-Si powder, which converts the hard aluminium oxide inclusions into relatively soft mixed oxides of the CaSiAl type and forms finely dispersed manganese sulphides, through which the swarf formed during machining is broken and thereby the service life of the tools is lengthened. A regulated sulphur addition only slightly diminishes the corrosion resistance of this embodiment of the steel alloy according to the invention.

According to the invention, there is at the most about 0.01 percent by weight, preferably at the most about 0.005 percent by weight, of niobium, based on the finished alloy. This content can be achieved by having regard to suitable scrap metal utilisation (avoidance of niobium containing steels) during the melting of the steel alloy according to the invention.

According to the invention, there is preferably at the most about 1.00 percent by weight, more preferably at the most about 0.40 percent by weight, of manganese, based on the finished alloy.

5 Phosphorus is originally derived from apatite or other phosphate containing minerals which were present in the iron ore. During smelting, phosphate can be reduced to iron phosphide (mainly Fe_2P) and may be present as such in the pig iron or subsequent steel. The preferably low phosphorus
10 content according to the invention of at the most 0.04 percent by weight and preferably of at the most 0.02 percent by weight, can be lowered during the production of the alloys according to the invention as is customary in the art, for example by CaO being added during smelting of the ore, so
15 that the phosphate-containing minerals are separated off in the slag.

The aluminium content according to the invention of at the most about 0.01 percent by weight, preferably at the most about 0.005 percent by weight, can be achieved if the
20 deoxidation required in the melting process is carried out not using aluminium, but rather using silicon or in the AOD or VOD process (see below).

There is preferably at the most 0.10 percent by weight, more preferably at the most 0.05 percent by weight,
25 of nickel, based on the finished alloy.

It is preferable for excess carbon, silicon and phosphorus to be removed simultaneously as is customary in the art, by refining with the addition of gaseous oxygen

(conversion into oxides) and the addition of CaO. Excess oxygen can then be removed in the usual way by carrying out refining in the form of VOD (Vacuum Oxygen Decarburization) or AOD (Argon Oxygen Decarburization) (removal of the excess
5 oxygen by degassing under a vacuum or by blowing it out with argon).

It is possible to set the titanium content according to the invention of at the most about 0.01 percent by weight, preferably at the most about 0.005 percent by weight,
10 especially preferably of at the most about 0.002 percent by weight, by the controlled use of scrap (avoidance of Ti-containing scrap, e.g. of Ti-containing steel No. 1.4571 known in the European context). As a further measure, it is possible to avoid Ti-impurities in the refractory lining of
15 the converters used during melting.

In the context of the present application, the term "remainder substantially iron" shall mean that the remaining percent by weight of the alloy as claimed in any one of claims 1 to 7, i.e. the percentages by weight which are not
20 made up of the elements mentioned by name in the corresponding claim, originate almost exclusively from iron (typically to an extent of at least 90 percent by weight, preferably at least 95 percent by weight and especially preferably at least 99 percent by weight or more of the
25 remainder).

The elements other than iron of the remainder should be chosen in a quantity so that the finished steel alloy according to the invention is ferritic. An initial basis for this is provided by the Schaeffler diagram mentioned at the

outset, with the aid of the nickel and chromium equivalent further elements worked out by Briggs and Parker. In individual cases, by means of experimental verification according to the measurement methods mentioned at the outset, 5 it can be determined whether the obtained alloy really is or is not ferritic according to the invention.

The alloys according to the invention can be produced by standard processes. Reference is made by way of example to Chapter 2 in the "steels" section of "Ullmann's Encyklopädie 10 der Technischen Chemie [Ullmann's Encyclopedia of Technical Chemistry]" 4th Edition, Verlag Chemie, and the literature cited therein.

During production of the steels according to the invention, it is preferable to carry out refining operations 15 using the AOD and VOD processes in succession; whereby the VOD refining can simultaneously also be used for nitriding.

With high-alloy steels, inhomogenities in the microstructure lead to punctiform accumulation of individual structural constituents. This can lead to undesired 20 variations in the microstructure formation and in the physical and mechanical properties. Preferably, therefore, in the production of the steel alloys according to the invention, as is customary in the art, annealings at temperatures from about 800 to 900°C, more preferably at 25 about 850°C, are carried out during the forging process, in order to avoid the punctiform accumulation of individual structural constituents and the accompanying formation of inhomogenities. The so-called "soaking" of the hot rolling slabs or extended pre-warm up time before the hot rolling are

recommended for this purpose.

Preferably the alloys according to the invention after forging or cold formation undergo an annealing at temperatures of 750 to 850°C, preferably about 800°C for about 0.5 to 2 hours, and then a water cooling. In this way, due to diffusion processes, the concentration of the chromium equilibrates in the matrix in the area of the finely dispersed, precipitated chromium nitride particles. The chromium nitride precipitation can, however, be largely inhibited by an optimization of the nitrogen content.

The steel alloys according to the invention can be polished reproducibly, by means of the processes which are customary in the watch industry, and would therefore be acceptable as a starting material for use in the watch industry. The nitrogen added to the alloy in a magnitude of up to 0.1%, is present, at the anneal temperatures, which are preferably used in the steel alloys according to the invention, either dissolved, or in the form of finely precipitated chromium nitrides, typically of a magnitude of approximately 1 μm , and therefore does not lead negative influences on the polishability.

The steels alloys according to the invention, in particular those of claims 3 to 7, typically have the following mechanical properties (metal sheets with thickness of 6 mm, hot rolled, annealed at 800°C for 30 minutes, quenched in water):

Yield strength $R_{p0.2}$	420 MPa
Tensile strength R_m	603 MPa

Elongation at break A_0	28%
Hardness HB 30	188

The alloys according to the invention are therefore comparable to the standard steel quality No. 1.4521.

5 By the addition according to the invention of nitrogen to the alloy instead of niobium or titanium, the precipitation of relatively large niobium carbides or titanium carbides, which destroy the polishability, is eliminated. Furthermore, the precipitation of chromium
10 carbides on the grain boundaries is inhibited. This occurs through an alteration of the precipitation kinetics, which brings about a precipitation of chromium nitrides, which is energetically preferred, instead of chromium carbides. In the case where the limit of solubility for nitrogen in the steel
15 alloy is exceeded, very finely dispersed chromium nitride particles with diameters around 1 μm and smaller precipitate, which, however, do not negatively influence the polishing characteristics owing to their fineness.

 Due to the low content of titanium and aluminium the
20 content on the associated oxides in the alloys according to the invention, as definable by test methods M (globular Oxide, DIN 50602), is correspondingly low. Through the nearly complete absence of titanium and niobium, the corresponding carbides are also almost completely lacking. On the other
25 hand, by the coordinated simultaneous addition of nitrogen together with the residual alloy elements other than chromium, essentially no precipitation of chromium carbides occurs and the alloy according to the invention is still ferritic, despite the increased content of nitrogen

(austenite-forming element). The purity grade of the steel alloy according to the invention of non-metallic oxide inclusions or carbide inclusions is altogether thus adjusted to such a high level, that a remelting according to the ESU-
5 method mentioned at the outset is not required any more; the remelting can however, if desired, nevertheless be carried out with the steel alloys according to the invention.

The steel alloys according to the invention are magnetically soft in the sense of the definition mentioned at
10 the outset.

The steel alloys preferred according to the invention of claims 3 to 7 exceed with their effective sum, as defined in the beginning, the minimal value required in medical technology for implant steels of 26.

15 Due to the good polishability and magnetically soft properties of the alloys according to the invention, these can be used in the watch industry for the production of magnetically shielded casing parts, for example for wristwatches or for other watches, in which a magnetic
20 shielding of the watch mechanism is important. The steel alloys according to the invention, in particular those of claim 7, are also suitable for the production of parts for linked watch straps.

The term "casing part" comprises in the context of the
25 present application the usual parts used as in the production of a watch casing, in particular a casing of a wristwatch, thus e.g. the casing base and the casing shell. The term "casing part" also however comprises in the context of the

present application, the watch face. The term "casing part" comprises the part as it appears in the finished watch, as well as any blank or a semi-finished product thereof, which is processed further by further processing, optionally also
5 using other materials or semi-finished products made from the alloy according to the invention or other materials, to produce the finished component.

Magnetically shielded watch casings according to the invention can consist of a casing base, a casing shell and a
10 watch face, which are all made out of the steel alloy according to the invention. The steel alloys according to the invention can therefore simultaneously be used as material for the parts, as well as a shielding cage against magnetic fields. The additional soft iron cage which is complex to
15 make, which has to be provided inside the usual casing out of non-magnetic CrNi-steel and which would lead to an increased height of the watch, can thereby be eliminated.

The steel variant 1.4521 according to the invention is eminently suitable for the powder metallurgic manufacture
20 using the MIM (Metal Injection Moulding) process, in particular because the nitrogen content required according to the invention can be supplied without problem during the compacting process (sintering) under a nitrogen atmosphere. The MIM process is known per se in the field of watch
25 production. To produce a watch component according to the invention, a steel alloy which contains the required elements in the final quantities, (these would be the elements which are named in any one of claims 1 to 7) but may not contain enough nitrogen, is milled to form a powder and suspended
30 using a liquid binder. This suspension is forced into a

mould, for example by means of an extruder, the mould cavity of which has the shape of the casing part that is to be produced. Then, the binder is evaporated, preferably in vacuo, and the powder residue that remains in the mould is
5 sintered. If the level of nitrogen in the alloy powder was initially insufficient, a nitrogen atmosphere of suitable pressure is applied during the sintering step, so that the alloy also takes up nitrogen during sintering. The choice of the suitable pressure of nitrogen to achieve a nitrogen
10 concentration in accordance with the invention in the finished casing part can be determined by a series of tests.

Production example

In the following an example for the production of a steel alloy according to the invention is given:

- 15 a) melting of approx. 5t in the induction furnace
- b) secondary metallurgy in the VOD converter
- c) continuous casting in slab form 1250 x 250 x 1270 mm
- d) chemical analysis
- e) preheating in a chamber furnace to rolling
20 temperature of approx. 1080°C
- f) initial rolling to a thickness of 120 mm
- g) grinding on all sides of the slab
- h) preheating in continuous furnace at 1080°C
- i) rolling on a four-high rolling stand to desired final
25 thickness of 3-12 mm
- j) annealing at 750-850°C
- k) quenching in water
- l) descaling
- m) testing the mechanical properties $R_{p0.2}$, R_m , A, Z

- n) metallographic determination of the grain size
- o) determination of the purity grade
- p) testing the polishability
- q) straightening
- 5 r) cutting to final dimensions
- s) release